REMARKS

Applicant has considered the official action mailed April 21, 2005 and respectfully submits that the claims are directed to patentable subject matter. Applicant thanks the Examiner for the consideration of the invention at the interview on June 27, 2005.

The sole outstanding rejection is of claims 31-35, 37 and 39-43 under 35 U.S.C. §103(a) over U.S. Patent No. 5,352,305 (Hester) in view of U.S. Patent No. 3,274,033 (Jacke).

The claimed invention is directed to a reworked metallic braking rotor or drum adapted to engage a brake pad or shoe in dry sliding contact and frictional loading comprising an ultrasonically impacted reworked braking rotor or drum presenting a smoothed, plastically deformed braking surface with a compressed sub-surface layer, thereby introducing or creating increased braking surface contact area. Claim 32 has been canceled in favor of incorporating the limitation thereof into claim 31. Dependent claims 33 and 35 are dependent on claim 31 and more specifically claim certain structural properties of the claimed braking rotor or drum. Claim 34 has been placed in independent form and is directed to a reworked metallic braking rotor or drum

wherein the rotor or drum has been ultrasonically reworked to provide a machined surface with a compressed sub-surface layer established by ultrasonic impact machining with a set of individual indenter elements randomly ultrasonically oscillating during contact with the drum or rotor surface. Claims 37 and 38 have been canceled and the subject matter incorporated into claim 40. Claim 40 is directed to a reworked metallic rotor or drum with an ultrasonically impacted braking surface with compressed sub-surface layer and defined surface roughness and stress profile.

A critical distinction between applicant's claimed reworked braking drum or rotor invention and the teachings of the applied art are that the claimed braking rotor or drum is an ultrasonically <u>impacted</u> reworked braking rotor or drum have at least a smoothed, plastically deformed braking surface with a compressed sub-surface layer. The structure present in the claimed braking rotor or drum based on being ultrasonically impacted is distinct from the articles described in either Hester or Jacke and is not suggested thereby.

More specifically, Hester teaches brake drums and rotors having surfaces machined by shot peening. Shot peening creates displacements of surface material about impact points to establish a rim pattern of roughened peaks

to mask former tool marks and tensile forces inherently introduced by the initial tooling procedure. Shot peening specifically roughens a braking surface and does not provide a normalized relief and a smoothed plastically deformed surface of the metal or ultrasonic plastic deformation of the metal underlying the surface. Hester does not teach or suggest an ultrasonically impacted reworked braking rotor or drum.

The Examiner relies on Jacke to make up for the shortcomings of Hester. The ultrasonic processing of a structure as described in Jacke is not capable of affecting the sub-surface material to provide applicant's claimed structure, i.e., a surface structure which is smoothed, plastically deformed and has a compressed sub-surface layer. Jacke teaches ultrasonic application to a solid metal at the surface by contact introduction (not impact with ultrasonic oscillations of indenter elements as claimed by applicant). Jacke specifically teaches at column 2, line 66 to column 3, line 6, that an ultrasonic horn transducer is pressed directly against the weld so that the tip of the horn transducer beats directly against the weld at the frequency of the transducer to introduce shock waves into the weld to reduce the forces between adjacent grains in the metal allowing them to rotate relative to one another.

Transfer (i.e., introduction, transformation) of ultrasonic oscillations and waves by impact is fundamentally distinct from transfer of ultrasound by contact. The structural effect on material during ultrasonic impact treatment is described below. During ultrasonic impact treatment, pulses of a random or aperiodic nature at an external work product surface creates stress waves within a material being treated. As this takes place, plastic deformation of the material occurs on and under the surface under the influence of dynamic forces at a frequency of "random movements" (impacts), while the ultrasonic oscillations of the impact elements and surface during these impacts result in ultrasonic stress waves that activate the processes of plastic deformation and relaxation of internal stresses (ultrasonic deformations and ultrasonic relaxation, respectively).

To illustrate the difference in the internal structure of an ultrasonically impact reworked braking rotor or drum as claimed as compared to the structure described in Jacke, the different structural characteristics will be described in relation to how they are provided since this shows that distinct structures are obtained. As to applicant's claimed invention, the impact induced compressive stresses and ultrasonic waves are generally

nondestructively transferred into the interior body material with an ultrasonically vibrating instrument located on an external surface zone of the body. Appropriate impulses of force at certain magnitudes and repetition rates and ultrasonic oscillations at a certain amplitude of ultrasound adapted for the particular shape and properties of the material of the braking rotor or drum are used for plastic deformation, structural modification and relaxation of internal stresses of the resident normally solid interior body material. Stress waves induced by the impulses of force and ultrasonic oscillations of impact elements with a plastically deformed surface are transferred inside the body during impact through the plastically deformed surface, activate the mobility of material structure fragments at macro, micro and nano levels, actuate the pulse mechanism of ultrasonic relaxation and ultrasonic plastic deformation, relax residual stresses and redistributes the stresses induced during treatment, modify the original crystalline structure and produce the material condition to reduce work product casting voids, rework grain structure, optimize residual stress field, introduce favorable compressive stresses and in the aggregate to produce the solid body material structure with improved performance. It should also be noted that during ultrasonic impact treatment the

material is quickly heated up to structural transformation temperatures and heat is also quickly removed from the area during a pause between impacts. In addition to the ultrasonic impact action mechanism described above, this is an additional tool in optimizing and controlling the properties and condition of the surface material. Thus, while the molten or plastic condition or long heat treatment process typically serves to relax residual stresses, remove voids and improve grain structure during heating and under high dynamic and static forces, the ultrasonic impact treatment in accordance with the claimed invention provides the same effect at an ambient temperature and with many-fold less energy consumption.

The oscillating system and the process of transferring shock pulse impacts to penetrate the work body structure is a critical tool for exciting stress waves in the material with the stress wave parameters being adequate to variations of internal material structure, redistributing and relaxing residual stresses, creating favorable plastic deformations and compressive stresses. Thus, an ultrasonically impacted surface of a braking rotor or drum has the claimed structure by the provision of an increased mobility at structural fragment boundaries at all structural levels by way of applied pulsed effect (on the structure) at

structure) at frequencies of random impacts and ultrasonic oscillations that are accompanied by the formation of a favorable stressed-deformed state of the material and, in particular, compressive stresses. Thus, residual stresses are relaxed and residual stresses introduced by ultrasonic impact treatment significantly strengthen the material. The resulting effect of ultrasonic impact treatment is a submicrostructure rearrangement of grains in treated areas.

The claimed smoothed, plastically deformed braking surface with compressed sub-surface layer is not effected by contact application of ultrasonic energy as taught in Jacke. As described in the captioned application in the paragraph bridging pages 32-33, ultrasonic impact of a previously machined and roughened braking surface induces a braking surface modification based on compressing a surface layer resulting in strengthening of the surface material to exceed the yield point of the base material to produce a surface compression strength during braking that exceeds the yield point of the brake drum or rotor material. Additionally, the topography at the surface is smoothed in its plastic state as impacting elements move across the surface to replace the tool marked surface structure with a smoothed frictional abutment surface structure with superior properties for engagement with brake pad frictional surfaces

under conditions of dry sliding contact with and frictional loading by brake pad surfaces. The deformation in an ultrasonically impacted structure is illustrated in Figures 7A-7D as described in the captioned application at pages 21-24.

With reference to FIGURE 7A, the classical stress-strain curve for the cast iron working material is illustrated with stress force F indicated on the vertical axis and deformation indicated on the horizontal axis. The curve represents three zones of deformation (I, II, and III) that are pertinent to the machining and service operation of the braking surface. This ultrasonic machining process imparts deformation to the surface at the zone closest to the ultimate strength of the material, typically cast iron, which is depicted as zone III on the curve.

FIGURE 7B represents the various levels of deformation within the braking surface as a result of ultrasonic impact as relates to the contact surface area with the brake pad. The contact surface area that is placed under load at the time of braking in contact with the brake pad is a surface layer of high strength material close to the ultimate strength of the base material. Beneath this protective high strength layer of material is a layer of

compressive strength material at its yield point categorized as deformation zone II in FIGURE 7A.

Thus, as diagrammatically set forth in FIGURE 7B, a force is applied in the maximum material strength zone III during application of the brake pad on the braking surface. To achieve this result, as depicted in FIGURE 7C, a small area impacting needle element striking and compressing the braking surface at a high velocity is employed in the ultrasonic impact machining of this invention. The prior art peening method, as represented in FIGURE 7D, uses a lower velocity, larger-area peening ball, deforms the surface into a crater and displaces the braking surface metal into a surrounding ridge ring to thereby roughen the braking surface with a maximum force in the yield point zone II as depicted in FIGURE 7A. The action of the peening ball does not allow for control at the point of impact. In many cases the shot peened balls are deflected during their travel from the desired trajectory by other balls ricocheting from the surface at time of treatment. This prevents control of the actual impact intensity. The nature of the peening process only provides for a single-component surface texture. Contact does not provide impact and also therefore does not provide structural modification of the braking rotor or drum resulting from impact.

With reference to the deformation characteristics of FIGURE 7A, the first plateau is formed when reworking forces reach the maximum level as the zone II fluidity of material forms plastic indentations of the material.

Contrast that with the zone III area where ultrasonic impact machining introduces deformation on the brake surface layer resulting in a strengthened material at a point close to the range 0.9 to 0.95 of the maximum cast iron material strength to achieve a substantial improvement in braking surface performance. The depth of this surface layer extends to a depth of the order of 12 mm thus to include the limits of braking wear depth. When applied by scanning the entire braking surface with impact needles, this assures a braking performance as illustrated in FIGURE 7B. The prior art methods of surface treatment forming areas of plastic deformation only extend to depths of about 2 to 3 mm and therefore cannot significantly improve braking wear life.

The plastic deformation of the claimed braking surface of the rotor or drum is realized by the frequency and duty cycles of the ultrasonic impacting elements, simultaneous pressure from impact of the tool upon the braking surface, inclination of the impact elements upon the braking surface, and the scanning (movement) speed of the

transducer (with impact needle) across the braking surface. This results in provision of a given degree of plastic deformation beyond yield strength and up to ultimate strength of the rotor or drum material. The plastic deformation in an ultrasonically impacted braking rotor or drum provides a distributed stress field counterbalanced in the volume of the brake rotor or drum of favorable residual stresses for cancellation of variable stresses incurred in service tending to cause thermo-mechanical fatigue of the rotor or drum during its operation.

An ultrasonically impacted braking rotor or drum has internally in adjacent sub-surface regions a normalized deflection mode of the material in the brake rotor or drum realized by balancing of internal forces.

Figure 3 of the captioned application illustrates the generation of randomly spaced ultrasonic impacts from a free flying impact member obtaining an up-to-task impulse of force from an ultrasonic transducer head which oscillates at an amplitude set by an operator and drives the impact elements which freely move in the guide holes and impact into a working surface. "Impact" therefore is clearly distinct from "contact" pressing as taught in Jacke.

As illustrated in Figure 2, the set of impacting elements 12', as driven by the transducer head 11,

ultrasonically plastically deforms as part of the machining process the surface 13 and the accompanying subsurface region 17 of a work body 15, typically a cast iron drum with an internally disposed cylindrical braking surface 13. The plastic deformations are induced on the braking surface and adjacent sub-surface body areas 17 permitting favorable stresses to compensate for tension stresses incurred during braking. The sub-surface effect is diagrammatically shown at 17 with separate working regions for the three impacting elements illustrated for the set 12', as deformation patterns, which are merged over the entire braking surface by appropriate movement of the transducer across the braking surface, thereby changing the nature of the material to an appropriate depth into the material being machined and forming a uniform pattern over the entire thus machined braking interface surface of the braking drum.

Accordingly, "ultrasonically impacted reworked braking rotor or drum" is distinct from a pressing contact directly against a material for ultrasound application as described in Jacke and shot peening as described in Hester. The above distinctions are further supported by the attached declaration of the inventor Dr. Efim S. Statnikov.

Accordingly, applicant submits that the combination of Hester and Jacke does not render obvious the claimed invention within the meaning of 35 U.S.C. §103.

Reconsideration and allowance of the claims is respectfully requested.

Respectfully submitted,

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Attachment - Declaration of Efim S. Statnikov